1.2 Single Barrel No. 771-16500

This particular barrel was not found, due mainly to complicating circumstances that occurred at the time the barrel was buried. A relatively large number of barrels (525) were moved in the attempt to find the second barrel. From 152 barrels in the particular load containing the sought after barrel, 30 were found early in the excavation in the area specified by the burial ground records, but the remaining were not found in the area excavated.

Figure 16 shows the area excavated in the search for the barrel. The search was made during two separate times, September 20-November 2 and November 8-November 10. The same problems that caused trouble in the first excavation were present in this excavation. However, despite leaky sludge drums, the soil was relatively clean.

Table VI summarizes the Pu content found in soil samples collected prior to excavation operations. One punctured sludge drum smeared 400 dpm, using the alpha scintillation crystal; 400 dpm was the highest contamination or smear encountered up to this time. This particular drum was repackaged in a larger 83-gal barrel.

TABLE VI

RESULTS OF SOIL SAMPLE ANALYSES FOR BARREL NO. 771-16500

Sample No.	Date Collected	Location[a]	Activity μCi Pu/g soil
V-CS-1	9-2-71	Pit 11, 127 ft E, 10 ft S of NW Monument	6.85×10^{-7}
V-CS-2	9-2-71	Pit 11, 127 ft E, 30 ft S of NW Monument	$<3 \times 10^{-7}$
V-CS-3	9-2-71	Pit 11, 127 ft E, 50 ft S of NW Monument	3.87×10^{-7}
V-CS-4	9-8-71	Pit 11, 127 ft E, 70 ft S of NW Monument	4.00×10^{-7}
V-CS-5	9-8-71	Pit 11, 127 ft E, 90 ft S of NW Monument	$<3 \times 10^{-7}$

[a] Samples taken above the barrels before the excavation started.

In addition to the scrap barrels containing U, Pu, and Am, several barrels were clearly marked as containing Be. No ruptured barrels containing Be were found, but certainly, special handling procedures are warranted for future large-scale operations because of the hazardous nature of Be.

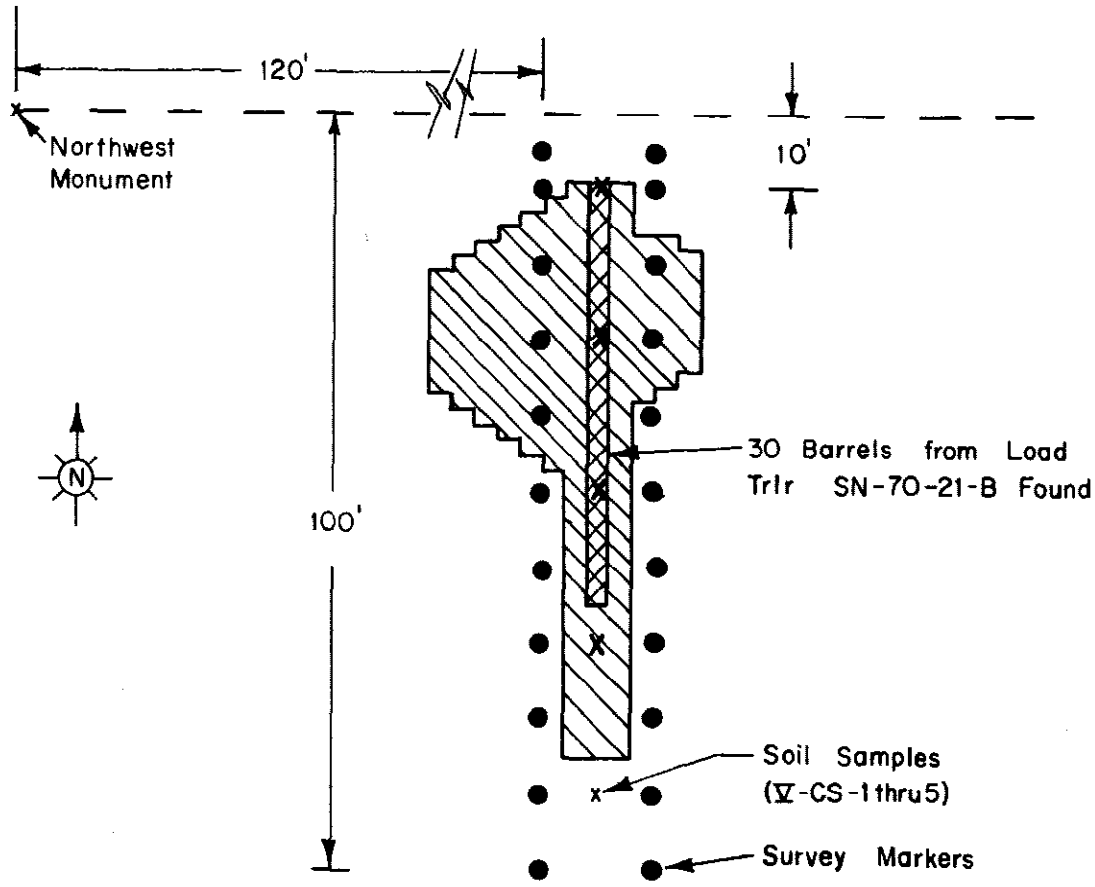


Fig. 16 Pit 11 excavation for special Barrel No. 771-16500.

Figure 17 shows the open excavation area just prior to widening the excavation at the north end of Pit 11. This pit was relatively simple to work, as the barrels were neatly stacked, and the pit area was not seriously contaminated. A road grader was used to remove approximately 18 in. of top cover during initial operations. Final dirt removal was done with a backhoe, and the barrels were removed using a crane and a chain barrel-hoisting device.

Table VII summarizes the overall operational information for this excavation. The highest ratio of barrels moved to manhours worked was achieved in this excavation.

TABLE VII

OPERATIONAL INFORMATION FROM THE SEARCH FOR BARREL NO. 771-16500

Dates of Excavation	9/20-11/2 and 11/8-11/10
Total Number of Barrels Moved	525
Number of Hours Spent Excavating	57
Number of Barrels Without Paper Labels or Metal Tags	11
Number of Repackaged 30-gal Drums	0
Number of Barrels Punctured	2
Number of Open Barrels (loose lid)	1
Manhours Direct Labor	230

1.3 Single Barrel No. 771-3431

The problems encountered in Pit 10 were many times those in Pit 11. The random nature of the barrels that resulted from "dumping" greatly complicated and slowed digging operations. Many seriously damaged barrels were found, some of which were open with the inner liner ruptured. Loose material--such as protective mask canisters, tags, plastic material, and barrel lids--were found. The main cause of the loose material and damaged barrels appears to have been the practice of dumping barrels. This practice resulted also in large portions of the pits (estimated at 50%) being filled with dirt instead of barrels.

The necessity of hand-digging and lifting barrels out resulted in only 24 barrels being exhumed over the 3-day period, from November 3 through November 5. Table VIII summarizes the work completed and the overall findings. About one-half the barrels were without identification, and about one-fourth were open--either without lids or with sides crushed. All the barrels suffered physical damage, due to leveling and covering by heavy equipment during burial. Corrosion, though present, did not appear to be a significant factor in the overall barrel condition. Neither Barrel No. 771-3431, nor the load that contained it, was found at the location designated by burial ground records. Figure 18 shows the area excavated in the search for this barrel.

Fig. 17 Excavation site for Barrel No. 771-16500.

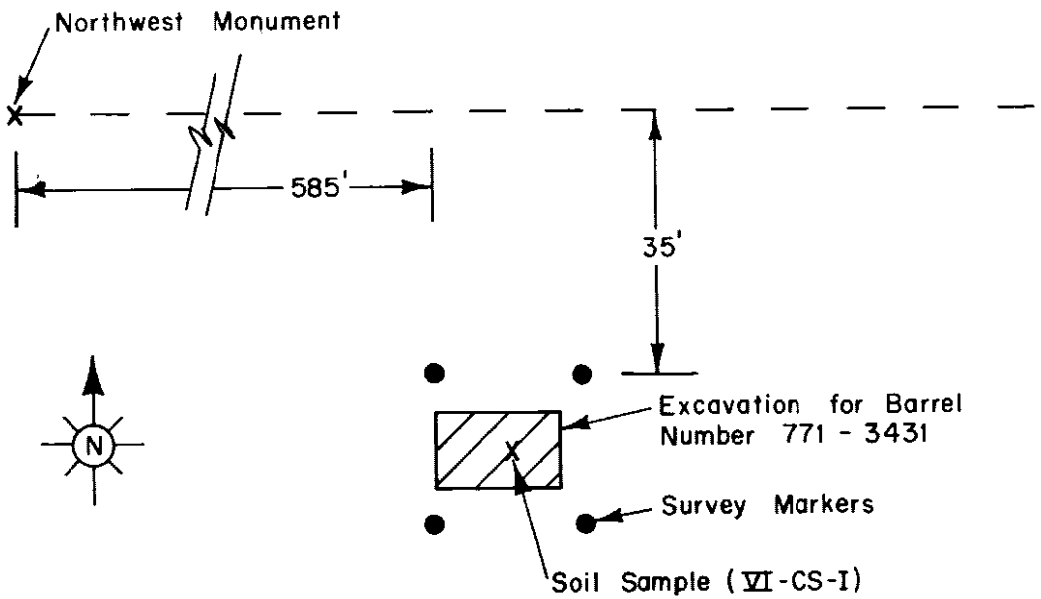


Fig. 18 Pit 10 excavation for special Barrel No. 771-3431.

TABLE VIII

OPERATIONAL INFORMATION FROM THE SEARCH FOR BARREL NO. 771-3431

Dates of Excavation	11/3/71 - 11/5/71
Total Number of Barrels Moved	27
Number of Hours Spent Excavating	15
Number of Barrels Without Paper Labels or Metal Tags	12
Number of Repacked 30-gal Drums	0
Number of Barrels Punctured	1
Number of Open Barrels (loose lid)	6[a]
Manhours Direct Labor	60

[a] Many others badly damaged.

This was the first excavation wherein dust respirators were routinely required by personnel. Whole-body counts of the two laborers who did most of the manual work showed no detectable Pu. A soil sample (IV-CS-I), taken prior to the excavation, showed low levels (6.22×10^{-7} μCi pu/g soil) of contamination. However, a special sample taken from excavated soil showed 2.28×10^{-4} μCi Pu/g soil, which was the first spot-check sample to show significant Pu contamination.

Figure 19 shows the poor condition of barrels removed from Pit 10. Even those barrels not seriously damaged showed the effects of heavy equipment used during burial.

2. MULTIPLE BARREL EXCAVATIONS

Table IX summarized the information used from the burial ground records for the multiple barrel sites. Some deviations from the original selections were made during the progress of SRWRT in the interest of time as inclement winter weather approached.

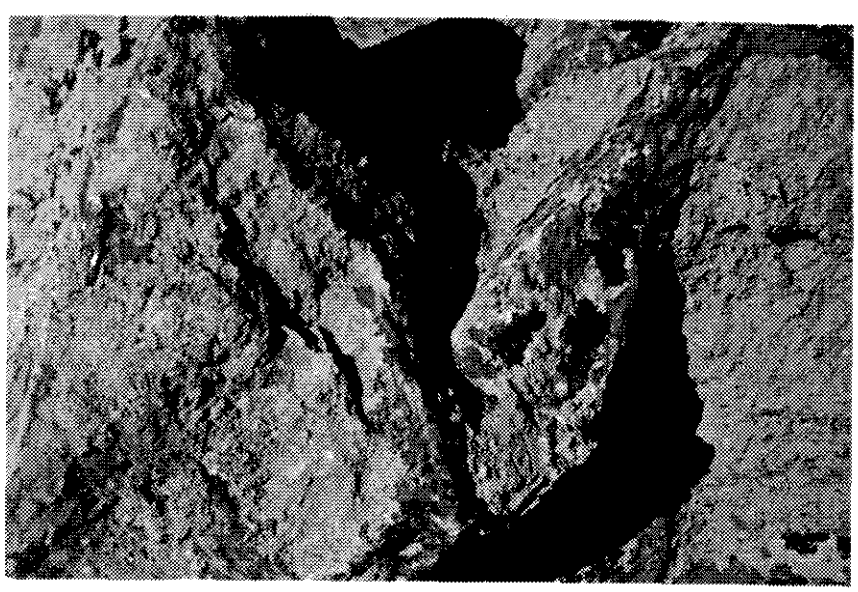
2.1 Excavation Work in Pit 11

Five barrels of waste material selected at random were removed from Pit 11 and transported to the ARA-I Hot Cell for the sorting and sampling phase of SRWRT. The five barrels included one sludge barrel and four barrels of miscellaneous waste and scrap. These barrels had been buried approximately one year.

A change from the original plan to remove the barrels from the west end of Pit 11 was instituted to save time. The barrels were taken from the edge of the excavation where the search for Barrel No. 771-16500 was made. By doing this, it was possible to look further for No. 771-16500 and also obtain selected barrels for the sorting and sampling studies.

The excavations in the region of Pit 11 were straight-forward in that the contamination levels were low, and the barrels were neatly stacked.

71 - 5417



71 - 5405

Fig. 19 Barrels removed from "dumped" Pit 10.

TABLE IX

INFORMATION FOR EXHUMING CONTAINERS FOR HOT CELL WORK

Record Item	Site 1	Site 2	Site 3
Location (pit)	11	5	2
Location Within Pit	20-25 ft E and 20-80 ft S of NW Monument	75 ft S of NW Monument	3 ft W of SE Monument, first row running N-S
Containers in Site (Pu Records)			
Wooden Boxes	0	4	0
Series 74 Sludge 55-gal Drums	35	-	37
Paper, Rags, etc, 55-gal Drums	35	84	115
Steel Tanks (special)	0	0	3
Volume of Waste, ft^3	528	1326	1146
Gross Weight, lb	29,704	28,025	38,443
Isotopic Contamination, g (in the load)			
Pu-239	478.8	Unknown	Unknown
Am-241	65.7	Unknown	Unknown
U	-	Unknown	Unknown
Containers Planned for Removal			
Boxes	0	1-2	0
Barrels	5-6	5	6-7

Figure 20 shows the bottoms of the five barrels removed from the pit as they were photographed in place. Leaky sludge barrels in the area which required careful survey caused some slowdown in the work.

Figure 21 shows the soil sample location and results of the soil sample analysis relative to the position of the barrels that were removed. The Pu contamination levels were between $<3 \times 10^{-7}$ μCi Pu/g soil (detection limit) and about 2×10^{-6} μCi Pu/g soil. The analyses indicate that the waste material contamination is well confined to the barrels and the soil immediately surrounding the barrels in Pit 11.

As might be expected from the soil contamination, and previous excavations in Pit 11, airborne contamination in this pit was not a problem. No detectable differences between gross alpha values for upwind and downwind air sampler filters were found.

2.2 Excavation Work in Pit 5

The second excavation to obtain barrels for the hot cell took place in Pit 5. Five waste barrels were exhumed for the hot cell studies. The waste containers in this pit had been "dumped" approximately seven years ago.

Figure 22 is a schematic of the excavation site. Initial efforts to open the pit up with bulldozer and scraper were futile in that waste was not located at the pit edge, as expected, but was found approximately 20 ft into the pit.

Figure 23 shows the excavation site prior to removal of barrels for hot cell testing. The random orientation and large quantity of dirt interspersed among the barrels is evident. About one-half of the volume of the area excavated was filled with dirt. In Pit 5, one-fourth of the barrels exhumed were opened (damaged or lidless). Several barrels were rebagged prior to removal, because they were punctured during digging or were rebagged and left in the excavation hole. Ten of the sixteen barrels exhumed could not be specifically identified. A summary of work activities at this site is given in Table X.

One sludge drum was creased at this site while lifting out another barrel with subsequent discharge of a clear liquid from the creased sludge barrel. Several Rocky Flats filters wrapped in plastic were found. The remnants of cardboard cartons which had contained the filters were found, also. A soil sample taken near the filter boxes showed Pu contamination of 1.14×10^{-3} μCi Pu/g soil. Direct radiation readings of 20 mR/hr were noted also at 3 ft from the filter boxes. No attempt was made to exhume the filters. Handling-equipment at the excavation site was deemed inadequate to contain potential contamination spread and prevent unnecessary exposure to personnel.

Figure 24 shows the soil sample location and results of the soil analysis for samples collected during the excavation. The analyses indicate that the general contamination level is quite low (about 1×10^{-5} to 1×10^{-6} μCi Pu/g soil) in the area and slightly higher than that found

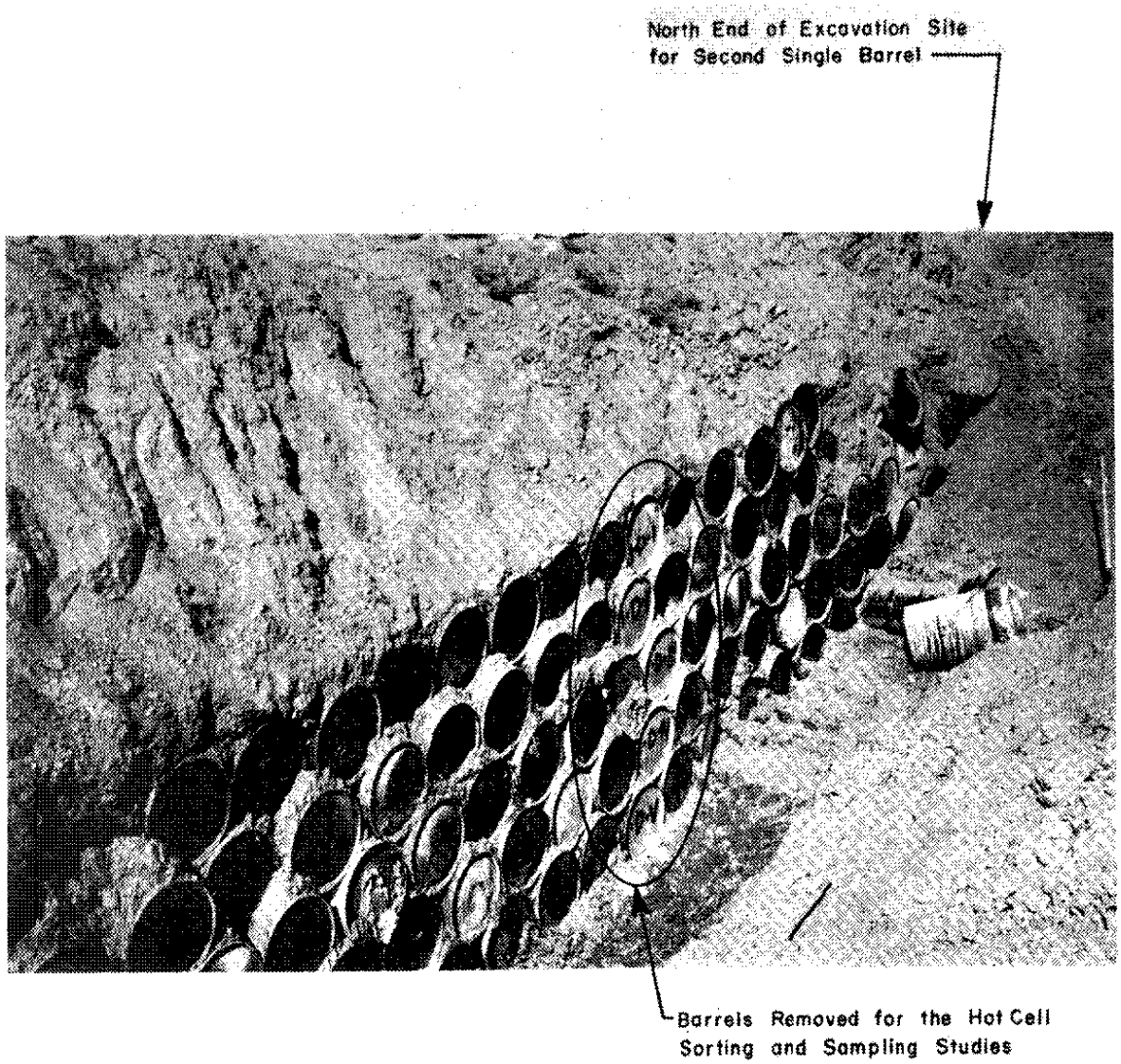


Fig. 20 First five barrels sent to the ARA-I Hot Cell.

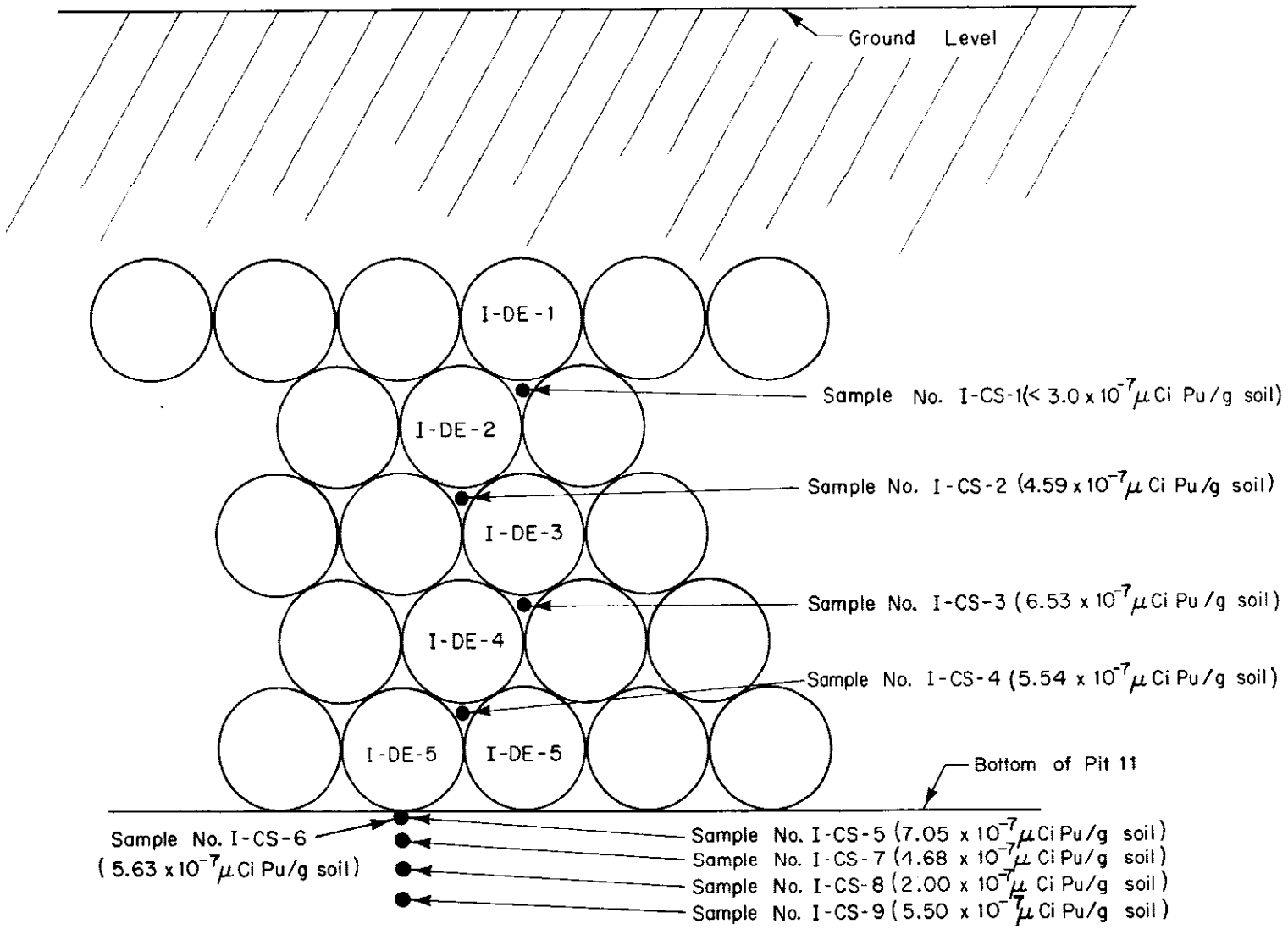
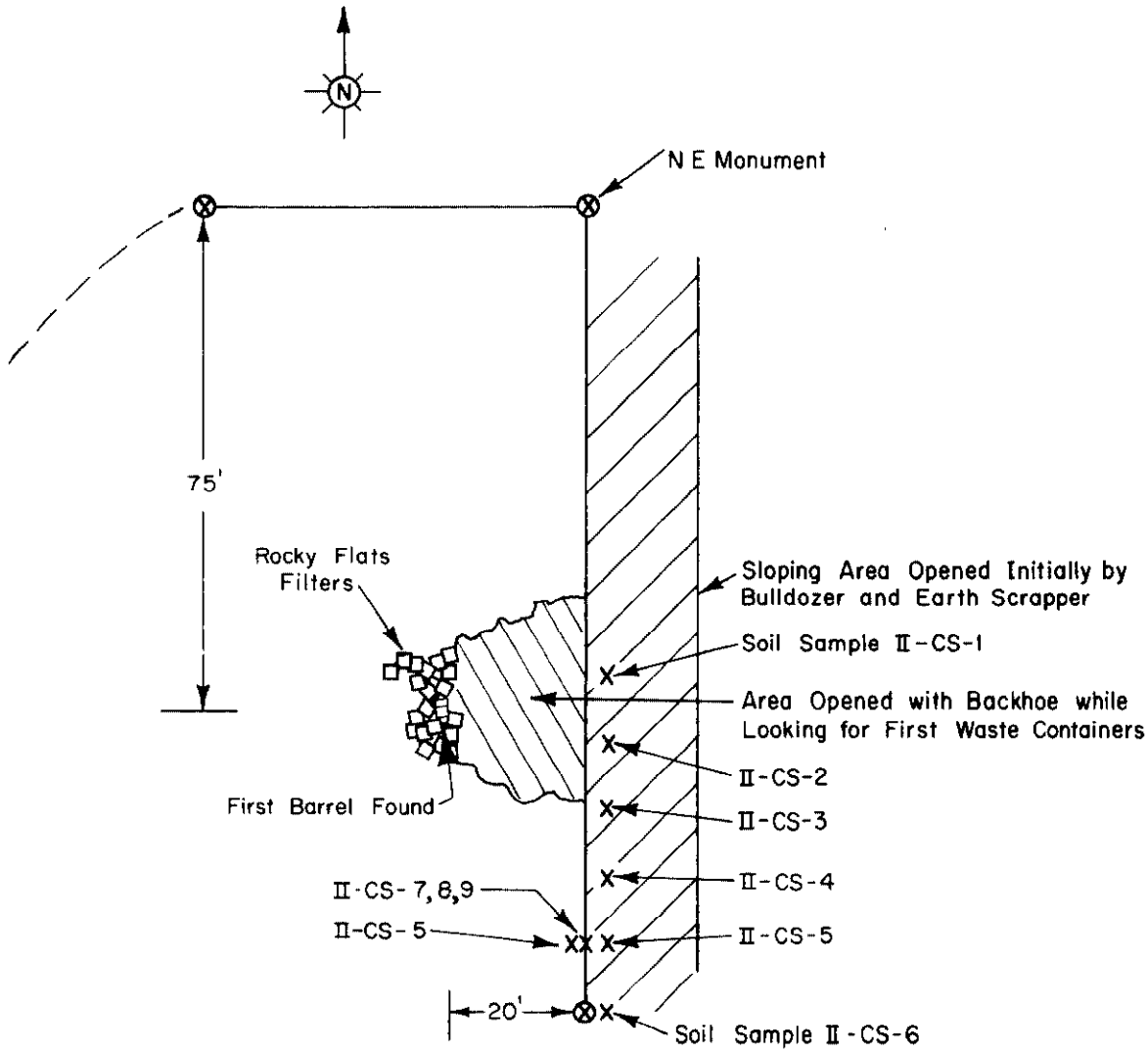


Fig. 21 Soil sample location and analytical values, Pit 11.



Soil Cover - 6 to 18 Inches
Soil Depth to Bedrock ~ 8 feet
Soil Type - Dry Hard Pan

Fig. 22 Schematic of Pit 5 barrel excavation.

TABLE X

OPERATIONAL INFORMATION FROM THE WORK IN PIT 5

Dates of Excavation	11/11 - 11/17
Total Number of Barrels Moved	16
Number of Hours Spent Excavating	24
Number of Barrels Without Paper Labels or Metal Tags	10
Number of Repackaged 30-gal Drums	0
Number of Barrels Punctured	2
Number of Open Barrels (loose lid)	4
Manhours direct labor	98
Barrels Readied for Hot Cell	5

in Pit 11. Analytical results from samples collected before the excavation are summarized in Table XI.

Waste boxes (4 ft by 4 ft by 7 ft) that were supposed to be located at this site, according to burial ground records, were not found. However, after completing the excavation in Pit 2, an effort was made to exhume a box from Pit 5. A box was found by checking sink-hole areas

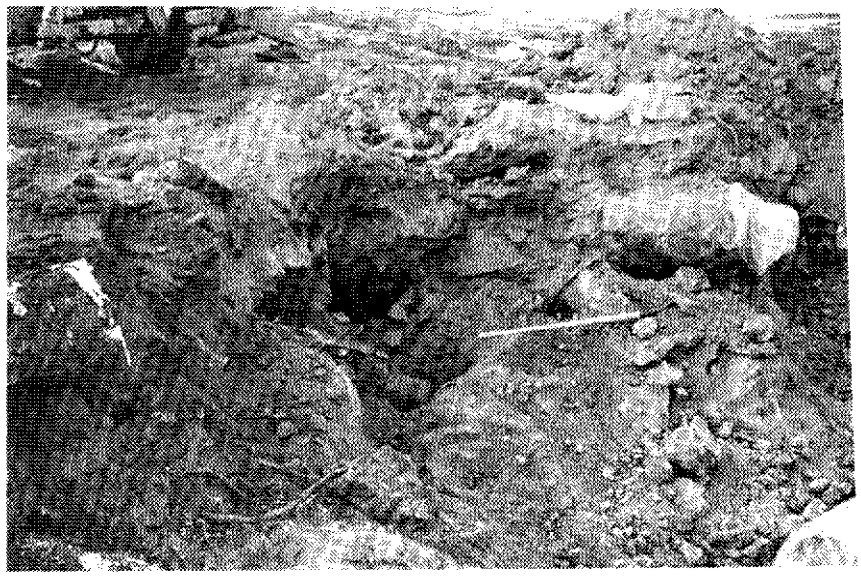


Fig. 23 Multiple barrel excavation, Pit 5.

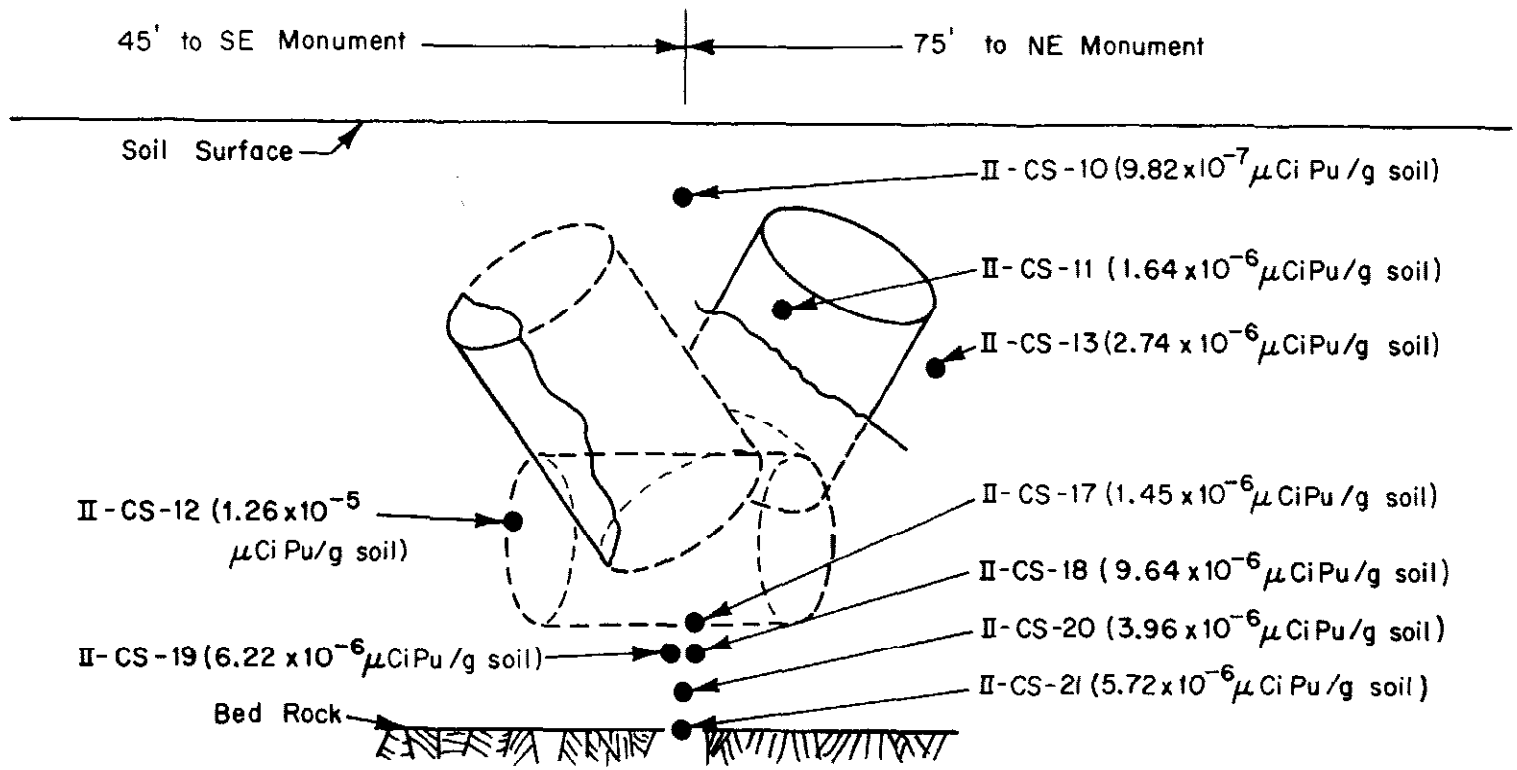


Fig. 24 Pit 5 excavation and sample location.

in the burial ground about 100 ft north of the southern boundary on a north-south center line. Soil cover was removed from the box by a backhoe and the top of the box cleared by hand-shoveling. The box, shown in Figure 25, was open, probably crushed by heavy equipment or soil covering, and in very poor condition. Pieces of the plywood lid to the box (1/2 in. plywood) could be torn off easily, and the main 2 in. by 4 in. support members were rotten. Internal plastic bags were damaged. The Health Physics smears showed about 1000 dpm. Because of the apparent overall high contamination levels and poor box condition, the box and contents were left in place. Future excavations in dumped pits where wooden boxes are involved probably will require special attention and the contents of the wooden boxes removed piece-by-piece.

TABLE XI

ANALYSES OF SOIL SAMPLES TAKEN FROM PIT 5

Sample No.	Date Collected	Location[a]	Activity µCi Pu/g soil
II-CS-1	9/17/71	See Figure 22 3 ft deep	5.82×10^{-7}
II-CS-2	9/17/71	See Figure 22 6 ft deep	1.59×10^{-7}
II-CS-3	9/17/71	See Figure 22 6 1/2 ft deep	6.56×10^{-7}
II-CS-4	--	No Sample Collected	--
II-CS-5	9/17-71	See Figure 22 8 ft deep	1.57×10^{-4}
II-CS-6	9/17/71	See Figure 22 7 ft deep	1.49×10^{-5}
II-CS-7[b]	9/27/71	See Figure 22 7 ft deep	2.96×10^{-6}
II-CS-8	9/27/71	See Figure 22 4 ft deep (hit rock)	8.65×10^{-6}
II-CS-9	9/27/71	See Figure 22 Surface at II-CS-7	2.39×10^{-6}

[a] Samples collected prior to start of excavation.

[b] Samples II-CS-7, 8, and 9 were taken to see if the high value of II-CS-5 was a localized or general contamination.

Three samples of soil were collected from the soil contacting the top of the box at the site and analyzed for Pu contamination. The results showed contamination levels of 5.58×10^{-7} µCi Pu/g soil, 2.55×10^{-6}, and 4.51×10^{-5} µCi Pu/g soil. These analyses do not verify the high levels of

contamination indicated by the Health Physics smears. However, this particular excavation was also the only site in which there was an airborne contamination of detectable significance. Fortunately, respirators were used throughout the work, and whole-body counts of the principal workers at the site showed no detectable Pu uptake. The difference between the upwind and downwind sampler filters showed an average airborne concentration of 6.75×10^{-12} μCi Pu/cc of air sampled over the 3-3/4 hours worked. This area was also the only site where detectable contamination was found on shoe covers. One shoe cover had a spot with 500 cpm, using a PAC-IS instrument. It is highly probable that this excavation represents one of the "hot spots" that might be encountered, as previously discussed.

Fig. 25 Pit 5 box excavation site.

2.3 Excavation Work in Pit 2

Six barrels were removed from Pit 2 (a stacked pit) and transported to the ARA-I Hot Cell for the sorting and sampling work. Excavations at this site were complicated by barrels which had been dumped along the edge of the pit outside the burial ground markers. The containers at this site were in the poorest condition of any encountered. Some of the barrels were corroded through, and sludge drums were leaking badly. On two occasions, clear liquid leaked from sludge drums. Some of the open barrels had no inner liners. The age of the containers is approximately 12 years.

Figure 26 is a schematic of the area excavated, showing the approximate location of barrels. Two of the barrels were 10 ft outside the burial ground pit markers. Several others also were outside the burial ground markers. The general condition of the barrels and potential for contamination slowed the exhuming operations markedly. The soil cover over the barrels at this site was about 12 to 18 in. Table XII summarizes information associated with work at the site.

Soil samples were collected and analyzed for Pu contamination. The results of these analyses and sample location are shown in Figure 27. One of the barrels, III-DE-4, was returned to the excavation hole, because it was a sludge drum which was leaking a clear liquid material. The soil contamination levels varied from about 1×10^{-3} to 1×10^{-6} μCi Pu/g soil. Contamination at this level made working conditions difficult in that respirators and frequent changes of protective clothing were required.

No detectable differences were observed between upwind and downwind filter samples. Modest levels of moisture in the soil may have contributed to the control of contamination in this area.

TABLE XII

OPERATIONAL INFORMATION FROM WORK AT PIT 2

Dates of Excavation	11/18/71 to 11/24/71
Total Number of Barrels Moved	24
Number of Hours Spent Excavating	15
Number of Barrels Without Paper Labels or Metal Tags	23
Number of Repacked 30-gal Drums	0
Number of Barrels Punctured	1
Number of Open Barrels (loose lid)	8
Manhours Direct Labor	60
Number of Barrels Readied for Hot Cell	6

Table XIII shows the wide range of Pu contamination found in samples collected prior to digging. Some difficulty in collecting samples was encountered when rocks and waste containers were found near the surface. Other soil samples collected prior to removal of the barrels for hot cell testing (Figure 26) shows that higher levels of Pu contamination were found in Pit 2, compared with Pits 5, 10, and 11.

3. RESULTS OF HOT CELL SORTING

Sixteen barrels exhumed from the NRTS Burial Ground were opened and qualitatively examined for general barrel and waste condition. The barrel condition varied from excellent (nominal corrosion) to poor (corroded through). In general, barrel condition was a function of age and method of handling during burial. Barrel liners exhibited a wide range of conditions from no liner to sealed with contamination well

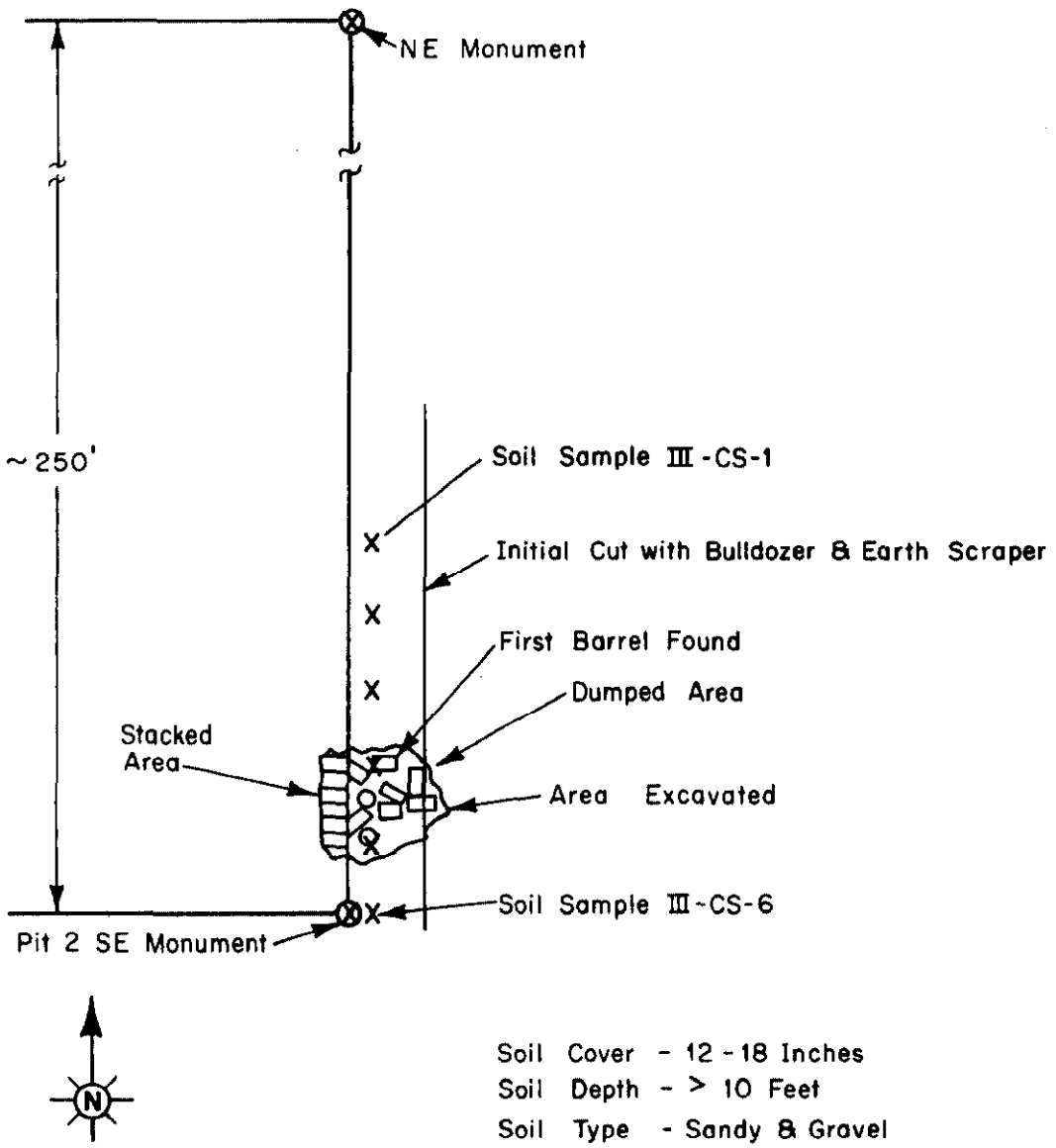


Fig. 26 Multiple barrel excavation, Pit 2.

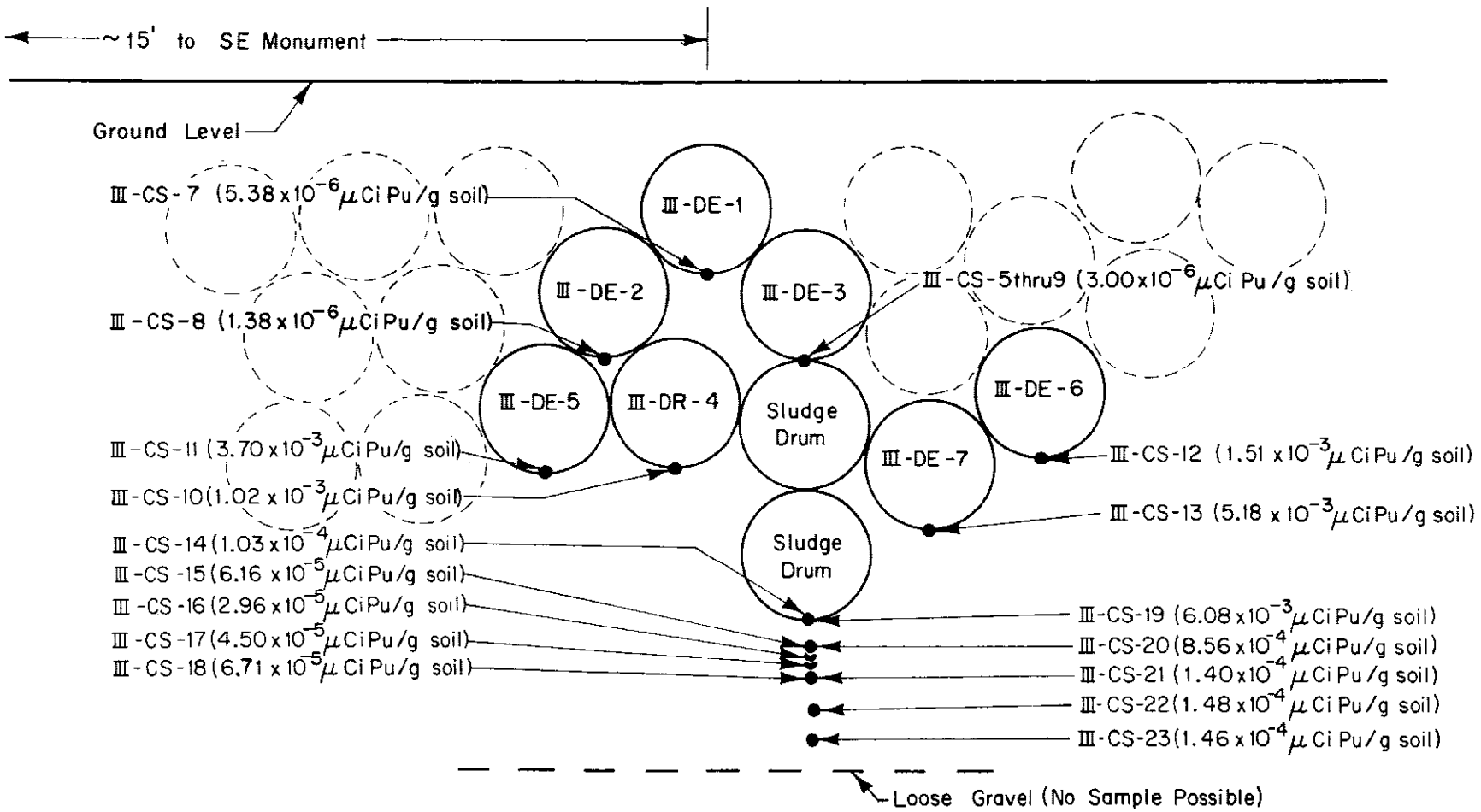


Fig. 27 Barrel and sample locations, Pit 2.

TABLE XIII

ANALYSES OF SOIL SAMPLES FROM PIT 2

Sample No.	Date Collected	Location[a]	Activity Ci Pu/g soil
III-CS-1	--	Not collected due to rocks	--
III-CS-2	--	Not collected due to rocks	--
III-CS-3	9/17/71	See Figure 26 3-1/2 ft deep	1.11×10^{-6}
III-CS-4	9/17/71	See Figure 26 9 ft deep	1.54×10^{-5}
III-CS-5	--	Hit rock at 2-1/2 ft No sample collected	--
III-CS-6	9/17/72	See Figure 26 7 ft deep	5.84×10^{-7}

[a] Samples collected prior to the start of excavation.

contained. The moisture content of the waste varied from dry to saturated with water puddled in the bottom of the barrel.

Table XIV is a summary of the observations made during the sorting and sampling phase of the SRWRT program. Those barrels identified as I-DE-1 through 5 had been buried approximately 18 months, II-DE-1 through 5, approximately 7 years, and III-DE-1 through 7 (except III-DE-4, which was not taken to the hot cell), approximately 12 years. With seven of the barrels, no Pu assay data were available, because the Rocky Flats identification numbers were not legible. The barrels were found to be 80% full (average of 16 barrels) with two barrels being 40% full and seven being 100% full. Based on the volume of material in the barrels, 37% was noncombustible (metal, wire, equipment), and 63% was combustible (paper, rags, rubber gloves, plastic, Kimwipes, etc). The barrels which had been buried 18 months were in good condition with light surface rusting. Ring closure were removed by unscrewing the fastening bolts. Those barrels in the 7 or 12-year buried group were heavily rusted with one barrel (III-DE-7) being completely rusted through. The bolts holding the ring closures in the older groups of barrels had to be cut off with a hacksaw. Nine of the sixteen barrels were not sealed, as evidenced by rubber sealing being out of position, obvious inleakage of water, or bent lid. The plastic bag barrel liners were in various conditions. Three barrels had no liner, five liners were folded over and not taped shut, three were taped shut but were punctured or rotted, and five were taped shut and intact. Two sets of Health Physics smears were taken for each barrel opened. The first was taken on and around the barrel lid, prior to removing the lid, and the other was taken on the underside of the lid and top of the waste just after the barrel lid

TABLE XIV

OBSERVATIONS OF BARREL CONTENTS DURING HOT CELL EXAMINATIONS

Rocky Flats Barrel No.	SRWRT Identification No.	Rocky Flats Assay g Pu/Barrel	Percent of Barrel Filled	Barrel Contents		Barrel Condition	Ring Closure Removal	Observed Barrel Seal Condition	Plastic Liner Condition	Smear Results Outside of Barrel (cpm)	Smear Results Inside of Barrel (cpm)	Moisture Observations	Comments and General Contents
				Percent Combustible	Percent Non-Combustible								
771-6724	I-DE-1	0	100	Unknown[a]	Unknown[a]	Good	Good	Sealed	None	<10[b]	20	Dry	Drum inside (not opened) sealed in concrete.
771-6727	I-DE-2	0	40	0	100	Good	Good	Not Sealed	Intact	<10	<10	Dry	Cardboard barrel of glass Raschig rings (double bagged).
771-7768	I-DE-3	25	50	50	50	Good	Good	Sealed	Intact	<10	<10	Damp	Loose surgeon's gloves and rags, 4 bags of rags and plastic, loose respirator cannisters.
771-7507	I-DE-4	53	80	80	20	Good	Good	Not Sealed	Not Sealed	<10	<10	Damp	No inner bags, surgeon's gloves, Kimwipes, rags, plastic, anti-C clothes, metal clamps, α probe face.
771-7633	I-DE-5	0	80	95	5	Good	Good	Not Sealed	Punctured	<10	<10	Damp	Loose material and inner bags open, surgeon's gloves, rags, Kimwipes, sheet rock, 2 x 4 boards, plastic sheet, paint cans, α probe face.
Unknown	II-DE-1	Unknown	80	75	25	Rusted	Cut Off	Sealed	Intact	100	<10	Puddled	One inner bag not sealed, surgeon's gloves, rags, plastic, Kimwipes, acid bottle, hand tools.
771-13273	II-DE-2	0	100	10	90	Bent, Rusted		Not Sealed	Not Sealed	90	55,000	Damp	No inner bags, paper, rags, metal angle iron, unistrut, tools, copper wire.
711-13237	II-DE-3	0	75	100	0	Rusted		Sealed	Punctured	<10	4,700	Puddled	Three of five inner bags ruptured, surgeon's gloves, wet rags, Kimwipes, plastic, shoecovers.
711-12327	II-DE-4	0	100	90	10	Rusted		Sealed	Intact	<10	120	Dry	No inner bags, cardboard, surgeon's gloves, rags, Celotex, Kimwipes, plastic, concrete, time cards.
771-13252	II-DE-5	0	100	50	50	Bent, Rusted		Not Sealed	Not Sealed	<10	<10	Damp	No inner bags, conduit, electrical wire (75%), surgeon's gloves, hose.
Unknown	III-DE-1	Unknown	80	100	0	Bent, Rusted		Not Sealed	Punctured	<10	<10	Puddled	Inner bag sealed holding fiber board barrel of graphite pieces.
Unknown	III-DE-2	Unknown	100	100	0	Rusted		Sealed	None	70	80	Dry	No inner bags, cardboard, plywood.
Unknown	III-DE-3	Unknown	80	0	100	Rusted		Not Sealed	None	<10	<10	Damp	Two small cardboard drums inside, pipe, tools, chempump, stand, glass.
Unknown	III-DE-5	Unknown	40	100	0	Rusted		Not Sealed	Intact	<10	118	Damp	No inner bags, cardboard barrel of graphite pieces (4 to 6 in. square).
Unknown	III-DE-6	Unknown	100	75	25	Rusted		Sealed	Not Sealed	80	<10	Puddled	Inner bags not sealed, surgeon's gloves, rags, Kimwipes, excelsior, packing material, 6-9 in. OD by 15 in. ss cylinders.
Unknown	III-DE-7	Unknown	100	25	75	Hole Rusted Through		Not Sealed	Not Sealed	14	38	Dry	No inner bags, 100 ft garden hose, 2 4-liter jugs, barrel lids, 7 in. OD ss cylinder, heavy mesh screen, metal stand.

[a] See Comments and General Contents Statement.

[b] Less than 10 cpm was in the range of background for the instrument used. No effort was made to refine measurements below this level, and the smears were considered clean.

was removed. Smears taken outside the barrel were of low value with a maximum of 100 cpm. The highest smear count was 55,000 cpm taken inside the lid of Barrel No. II-DE-5. Four barrels had water standing in the bottom, and five were dry. The remaining seven barrels were damp, due to wet Kimwipes and rags found inside or from water that leaked into the barrel.

For the barrels that could be identified by Rocky Flats numbers, the contents were found to be as stated in the Rocky Flats records. Knowledge of the contents of the barrels will be needed to enable accurate assaying of the barrels for Pu content.

4. COST ESTIMATES FOR RETRIEVAL

The cost for retrieval of waste barrels in the SRWRT program, based on the number of barrels exhumed and direct labor for exhuming, are shown in Table XV. Direct labor hours include all personnel required to lift barrels out of the pit area; ie, health physicists, laborers, and equipment operators. Based on this cost experience, one can extrapolate similar costs for exhuming the burial ground on a larger scale. Assuming that 1/3 of the barrels in the burial ground are stacked, and 2/3 are dumped, and assuming a cost of \$10/manhour of direct labor, results in a cost of \$3.33/ft^3 of waste for large-scale exhuming operations. These costs may not be optimal for large-scale operations.

The cost experience from the SRWRT program shows that exhuming waste from dumped pits is higher than exhuming wastes from stacked pits. The cost of exhuming barrels in the stacked pits, while searching for Barrel Nos. 771-7285 and 771-16500 and retrieving barrels for hot cell sorting from Pit 11, was between \$4 and \$5 per barrel. The cost of exhuming barrels from dumped pits in the search for Barrel No. 771-3431 and barrels for hot cell sorting in Pit 5 was \$22 and \$60 per barrel, respectively. The cost of exhuming barrels for hot cell sorting from stacked Pit 2 was \$25 per barrel. The Pit 2 costs were notably higher than other stacked pits, because barrels had been dumped at the edge of this pit where the excavation was started. It is probable that complete excavation of Pit 2 would result in costs more nearly equal to those of other stacked pits.

TABLE XV

RETRIEVAL COSTS

Excavation Site	Type of Pit	Barrels Exhumed	Number of Direct Labor Hours	\$/Barrel
771-7285	Stacked	185	92	5
771-16500	Stacked	525	230	4.3
771-3431	Dumped	27	60	22
Pit 11[a]	Stacked	--	--	--
Pit 5	Dumped	16	98	60
Pit 2	Stacked	24	60	25

[a] Included with single Barrel No. 71-76500 site.

V. CONCLUSIONS

A major conclusion of this work is that the Rocky Flats waste stored at the NRTS Burial Ground can be exhumed and handled safely. The tests clearly demonstrated that the wastes could be exhumed and handled without spread of Pu contamination and without endangering operating personnel or the general public. Some of the wastes encountered were more difficult and costly than others to exhume, depending on:

(1) Length of time the waste was buried

(2) Type of burial (dumped or stacked)

(3) Type of container (barrel, box, or cardboard carton)

(4) Condition of the waste.

Container Condition and Soil Contamination:

Barrels which have been buried up to 18 months in a stacked pit were in good condition and could be identified by Rocky Flats labels (>95% were identified). Some of these barrels contained sludge or salt material that leaked, but the low levels of Pu in these types of barrels made it possible to continue with minimum difficulty. Contamination in the soil adjacent ot these barrels varied between $<3 \times 10^{-7}$ (detection limit for CPP analysis) to 1×10^{-6} μCi Pu/g soil. This level of contamination corresponds to levels resulting from weapons-testing fallout and does not impose a threat.

Barrels which were buried from three to seven years in dumped pits were considerably more difficult to exhume than those in the stacked pits. The main contributing factors were the random barrel orientation and the damage that the barrels incurred during the dumping operations. Identification of only 40% of these barrels from Rocky Flats tags was possible. Open barrels and leaking sludge-salt barrels resulted in Pu contamination levels approximately one order of magnitude higher than the 18-month old stacked pits. The contamination level was about 1×10^{-5} to 1×10^{-6} μCi Pu/g soil, which poses no particular problem to excavation efforts.

Waste containers which were stored in stacked pits for 12 years were in poor condition, due mainly to corrosion. Contamination levels were as high as 5×10^{-3} μCi Pu/g soil in this area, which did not stop exhuming efforts but resulted in the use of half-face respirators by workers in the area.

Efforts to exhume a plywood box which was about five years old were thwarted because of the poor condition of the box and apparent high-contamination levels indicated by Health Physics smears. Actual soil samples showed contamination levels in the area in the range of 5×10^{-6} to 5×10^{-7} μCi Pu/g soil; however, slight amounts of airborne contamination were encountered.

Cardboard cartons containing Rocky Flats filters were found with the barrels which had been buried about seven years. The cardboard was disintegrated, and soil contamination was relatively high (1×10^{-3} to 1×10^{-4} μCi Pu/g soil). These types of containers represent special cases requiring additional handling precautions and techniques.

Criteria for removing contaminated soil from the NRTS Burial Ground have not been established. However, the Task Force on Sorting of Radioactive Waste[10] has recommended continued burial of wastes (at carefully selected sites) whose concentration is less than 10 nCi/g. No soil sample collected during the SRWRT program was greater than about 5×10^{-3} μCi Pu/g soil or 5 nCi/g soil. With the Task Force recommendation as a guideline, it appears unnecessary to remove soil from the NRTS Burial Ground for the areas sampled. This approach seems appropriate, based on the facts that (a) the NRTS Burial Ground is a carefully selected site, (b) migration of plutonium in the soil is limited, and (c) small total quantities of Pu are involved. This conclusion does not preclude the possibility of finding higher soil concentrations in "hot spots" of Pu wherein the soil would have to be removed. The conclusion from the SRWRT program is that gross quantities of soil should not have to be removed, pending better definition of the criteria.

Migration of the Pu contamination was limited. Most of the contamination outside the barrels was found within six inches of the waste containers. At the oldest site excavated, contamination of about 1×10^{-4} μCi Pu/g or 0.1 nCi/g soil was found 3 ft below the barrels. This level of contamination is 1/100 the value recommended by the Task Force on Sorting of Solid Radioactive Wastes for special treatment.

Health Physics:

Eberline instruments (PAC-1S, etc) were inadequate to measure contamination in the field. Smears counted in a scintillation crystal detector were required for detection of most of the contamination encountered. Half-face respirators were satisfactory in preventing worker inhalation of Pu. Whole-body counting using special detectors for Pu showed no detectable Pu intake for the main workers. Single layers of anti-C clothing consisting of coveralls, rubber or canvas shoe covers, and cotton gloves were satisfactory in preventing skin contamination.

Double bagging of contaminated or leaking barrels in plastic was adequate to prevent spread of contamination while the containers were loaded into a dumpster for transport to and from the ARA-I Hot Cell, during transport, and during storage at the hot cell. Some drums, particularly sludge drums which leaked clear liquid, were repacked in 83-gal barrels without difficulty.

Excavation:

A backhoe with a 3/8-1/2 cu yd bucket was the most effective piece of equipment for uncovering barrels. Other equipment, such as a bulldozer, resulted in excessive damage to waste containers. Hand-shoveling in the immediate vicinity of the containers was employed in all cases and was

necessary to prevent container damage. Bulldozers and other heavy equipment were satisfactory for backfilling and limited removal of overburden. Contamination control was not a serious problem at any of the excavation sites. Modest amounts of soil moisture probably helped to hold contamination spread to a minimum. Wind up to 20 mph apparently does not resuspend the Pu in the soil during barrel excavation operation.

Excavation teams consisting of one or two laborers, one equipment operator, one health physicist, and one technical man were effective in waste container removal. However, the lack of knowledge of the potential hazards involved on the part of laborers and equipment operators was evident and would have to be remedied by extensive training for large-scale operations.

Hot Cell Sorting:

Waste inside the barrels which were sorted at the ARA-I Hot Cell was found in various states of packaging. Some waste was uncontained in the barrel (no liner). Other waste was contained, but saturated with moisture, and the barrel liner broken or unsealed. Waste was mixed--combustible with noncombustible. The mode of packaging waste obviously changed over the years; newer wastes had been packaged more carefully. No uncontrolled spread of contamination or personnel exposure resulted from handling wastes in the hot cell and containment system that was used.

Facilities and Procedures:

Facilities at the NRTS Burial Ground are not adequate presently for a waste exhuming operation of any magnitude. The lack of electrical power, water, support facilities, and communications hampered retrieval work. The facilities at ARA where sorting operations were conducted were adequate for limited operations, though not specifically designed for alpha work.

Procedures were developed which will form the basis for future operations on a large scale. Minor modifications for bulk handling may be required, but the fundamentals were established.

Costs:

Based on the costs encountered in the SRWRT program, a large-scale exhuming operation is estimated to cost about $\$3.33/ft^3$ of waste exhumed. This cost is derived from direct labor involved, which includes health physicists, laborers, and equipment operators and a ratio of two dumped barrels to one stacked barrel in the burial ground. This cost does not include administration, analytical, or other supporting activities and should not necessarily be considered optimal.

VI. RECOMMENDATIONS

The best approach for exhuming Rocky Flats wastes from the NRTS Burial Ground appears to be the use of excavation teams consisting of an equipment operator, laborers, and a health physicist. However, based on the large quantities of material to be move, it may be desirable to study mass excavation techniques. The main problems with mass excavation techniques are contamination control in areas where cardboard cartons and wooden boxes are buried and the interspersion of the cardboard cartons and wooden boxes with barrels.

The existing facilities at the burial ground are inadequate to support a large-scale exhuming operation. A facility where administrative, health physics, accountability, and security functions could be performed is needed. Personnel and equipment decontamination, equipment repair, and fire fighting equipment should be sited at the burial ground to support a large-scale exhuming operation.

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